# UMENTATION PAGE

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An Investigation of the Channel Crosstalk in Optical Heterodyne Controlled Phased Array Radars.

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**ABSTRACT** *(Maximum 200 words)*

The principal objective of this project is to investigate problems associated with achieving the drive/read-out system complexity necessary to control a phased array antenna with optical heterodyne techniques. The approach has been to study the problems associated with device arrays of single sideband modulators that would be necessary to control the amplitudes and phases of all signals delivered to a phased array front end. However, recent results of closely related research, when combined with results of this project, have led to a new viewpoint of the problem. It appears that a greater degree of complexity of control can be achieved by modulating a small number of optical channels and locking them to a previously self-locked array of active radiating elements. This approach promises to lead to a better system solution as well as a technical study which uncovers many new interesting problems in the computer aided analysis of nonlinear electromagnetic systems.





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# SEMI-ANNUAL PROGRESS REPORT

for Office of Naval Research
for the period December 1,1992 through May 31, 1993



1. **Contract Title:**
An Investigation of the Channel Crosstalk in Optical Heterodyne Controlled Phased Array Radars



**Principal Investigator:**
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**Program Manager:**
Dr. Arthur Jordan

2. **Technical Objectives:**
The principal objective of this project is to investigate problems associated with achieving the drive/read-out system complexity necessary to control a phased array antenna with optical heterodyne techniques. In particular, this work concentrates on multi-channel microwave optical conversion.

3. **Approach:**
The approach has been to study the problems associated with device arrays of single sideband modulators that would be necessary to control the amplitudes and phases of all signals delivered to a phased array front end. However, recent results of closely related research, when combined with results of this project, have led to a new viewpoint of the problem. It appears that a greater degree of complexity of control can be achieved by modulating a small number of optical channels and locking them to a previously self-locked array of active radiating elements. This approach promises to lead to a better system solution as well as a technical study which uncovers many new interesting problems in the computer aided analysis of nonlinear electromagnetic systems.

4. **Accomplishments:**
Closely allied research in the MIMICAD center has led to the development of a electromagnetic analysis technique called "ZOOM" which is significantly faster than full wave techniques. This computer aided technique offers several advantages over competing methods while not sacrificing any of the accuracy of full wave techniques, at least, when the analysis of non-uniform coplanar waveguide structures in a simple mode is considered. The first reference of section 7 details this technique which is based on combining quasi static analysis with a "bootstrapping" dynamical fix-up based Ricatti equation solutions.

One motivation for developing "ZOOM" was the existence of our technique for mapping the amplitude and phase of microwave fields throughout substrates.

This technique was applied to an active surface during this period (see b and d of section 7) with quite surprising results. Electromagnetic theory predicted Floquet mode currents while measurements indicated currents periodic in the element spacing rather than in the wavelength. This surprising result seems to be explainable by the non-linear nature of the line under consideration and how the nonlinearity leads to a current "phase transition" as the oscillation power is increased.

Optical Injection locking measurements made on field effect transistor (FET) oscillator circuits have demonstrated the efficacy of locking microwave elements to a control signal through optical means. Even with a weak control oscillator, low modulation index, and low power injection level, large amounts of power can be locked precisely to the weak control oscillator.

## 5. Significance:

The form of the measured current distribution along with the oscillator locking results indicate that a small number of optically injected signals can efficiently control a large number of active high power antenna elements. A working understanding of such an array will require effective electromagnetic modeling as evidenced by the unexpected current distribution result. A most positive attribute of the program "ZOOM" is its ability to easily interface with highly nonlinear line elements. By combining "ZOOM" with simple nonlinear FET models it should be possible to make an electromagnetic model in which the nonlinearity plays a fundamental role in system behavior of optically addressed active antenna elements.

## 6. Future Efforts:

Present work involves trying to physically understand locked array results while simultaneously trying to modify existent software to accurately analyze optically addressed antenna elements.

## 7. Publications and Presentations Partially Supported Under This Grant December 1, 1992 through May 31, 1993.

a) K.Y. Chen, P. Biernacki, Z.B. Popovic, and A.R. Mickelson, "Current and Field Distribution Across A 25-Hemt Grid Oscillator," National Radio Science Meeting, URSI, Boulder (January 1993).

b) D.R. Hjelme, V. Radisic, Z.B. Popovic, and A.R. Mickelson, "Experimentally Verifiable Modeling of Parasitics in Coplanar Waveguides," National Radio Science Meeting, URSI, Boulder (January 1993).

c) S.L. Kwiatkowski, D.R. Hjelme, and A.R. Mickelson, "Optical Waveguide Lenses for Integrated Optical Components," National Radio Science Meeting, URSI, Boulder (January 1993).

d) E. Primas, V. Jevremovic, A.R. Mickelson, and Z. B. Popovic, "Microwave Characterization of Polymeric Materials for Electro-Optic Devices," National Radio Science Meeting, URSI, Boulder (January 1993).

e) S. Lin, W. Feng, H.B. Hooker, Z.B. Popovic, and A.R. Mickelson, "Polymeric Materials Processing and Optical Properties of High Speed Modulators," National Radio Science Meeting, URSI, Boulder (January 1993).

f) S.M. Genco, J. Buetow, Z.B. Popovic, and A.R. Mickelson, "Enhanced SNR and Stability of Microwave MESFET Oscillators via Optically Injected Signals," National Radio Science Meeting, URSI, Boulder (January 1993).

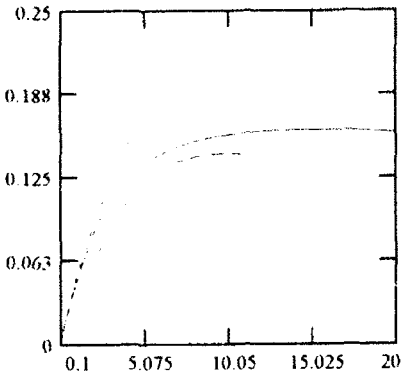
## Guided Wave Optics Laboratory Reports

D.R. Hjelme, V. Radisic, Z.B. Popovic, and A.R. Mickelson, "Experimentally Verifiable Modeling of Coplanar WaveGuide Discontinuities," submitted to IEEE Microwave Theory and Techniques (1993).

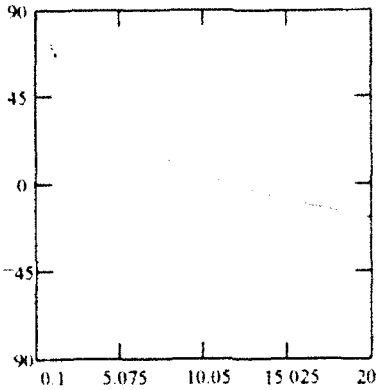
## 8. Participants:

Professor Alan R. Mickelson
Hyesook Hong

## Comparison of Calcualted and Data Sheet S-parameters vs Frequency (GHz)




Calculated |S12|
Fujitsu, FLO16XV
Fujitsu, FSC11X
Avantek, ATF10236

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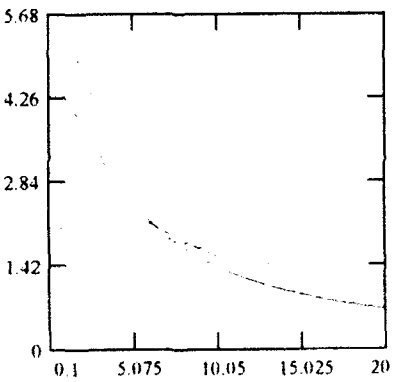
Fujitsu, FSC11X
Avantek, ATF10236

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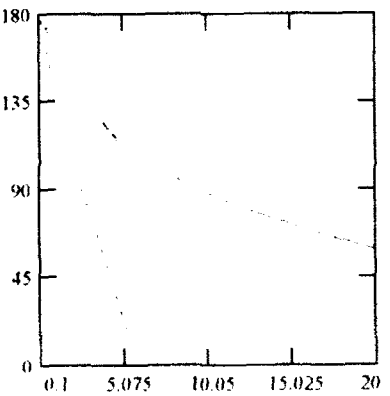


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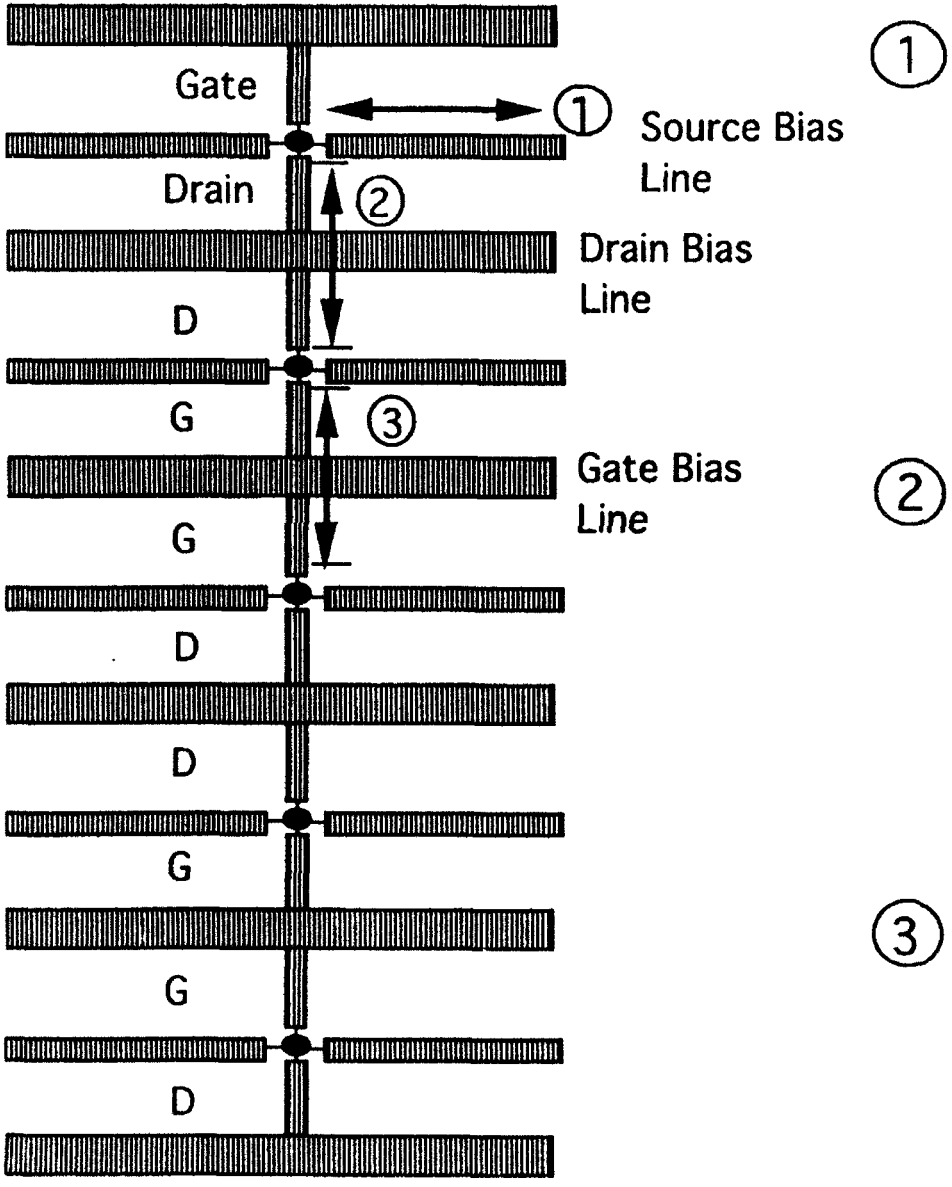
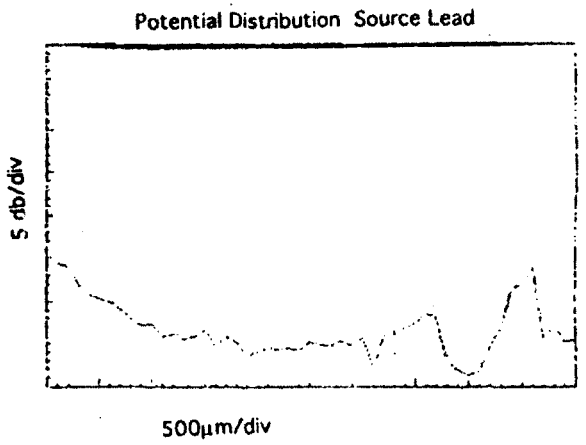
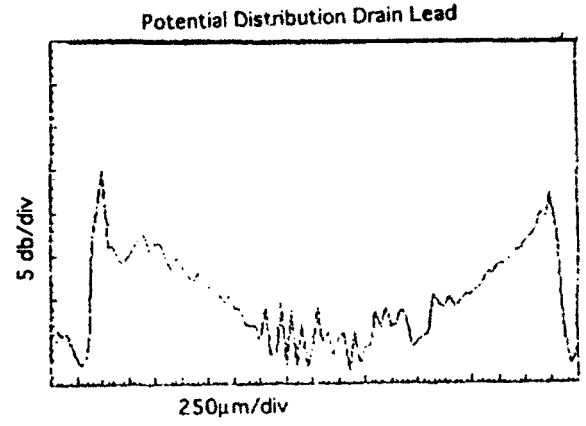
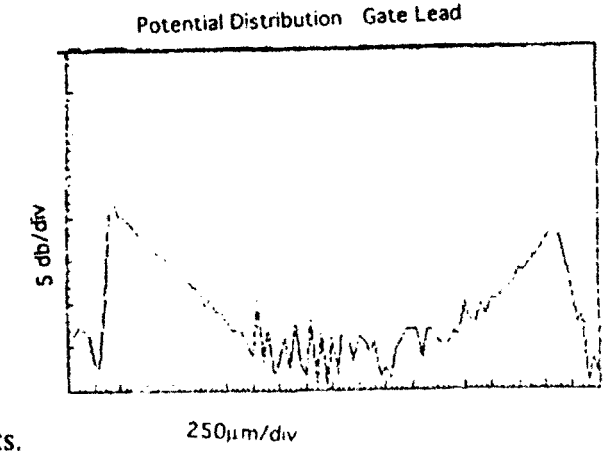
Avantek, ATF10236

# Measurements along 3 rd column




Current distributions can be extracted from these potential distribution measurements.